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FOR MANAGEMENT IN ELECTRONICS, COMPUTER & SYSTEMS COMPANIES — WORLDWIDE

FEBRUARY 6, 1989

HEADACHE FOR HYUNDAI

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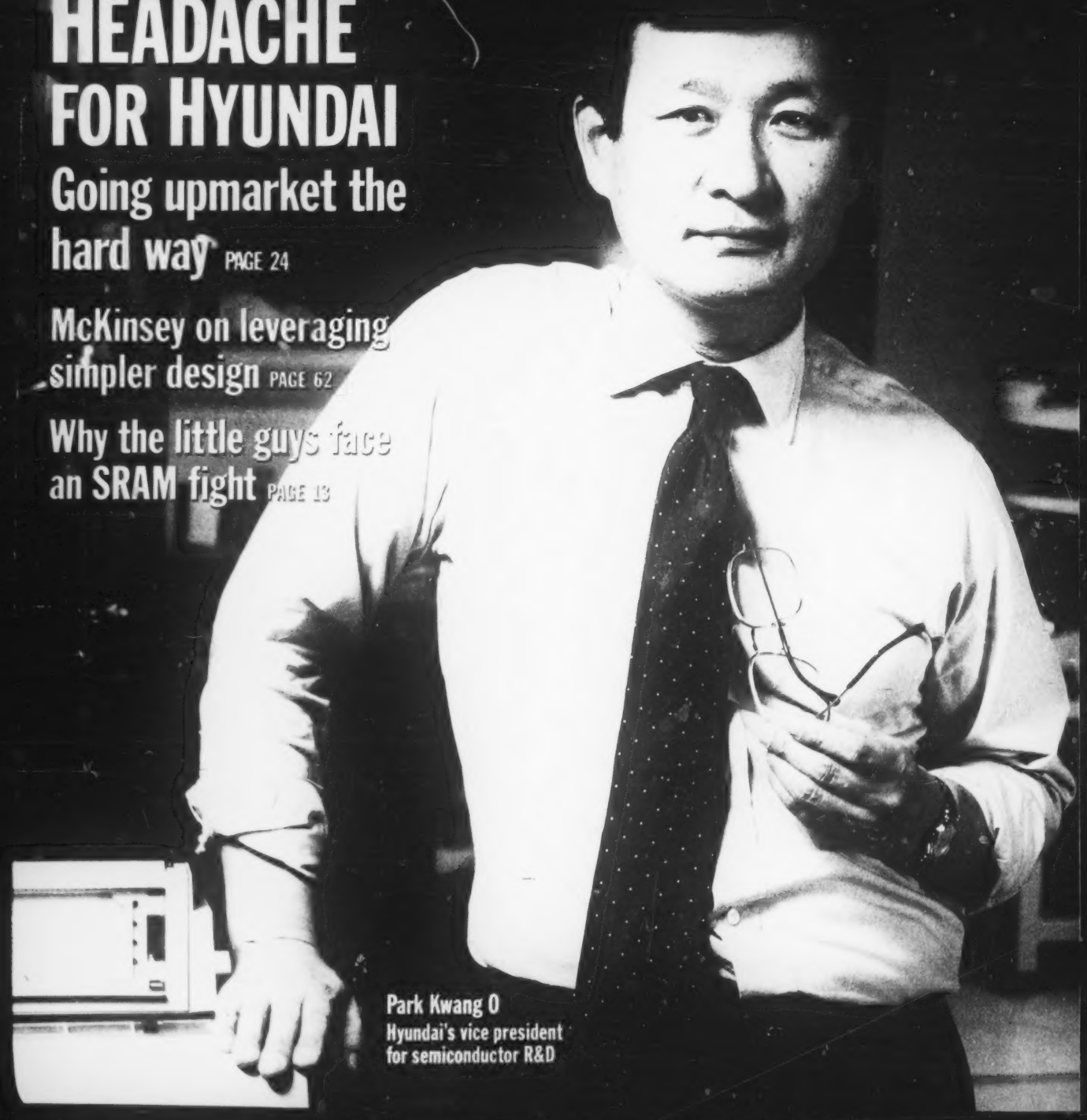

Park Kwang O
Hyundai's vice president for semiconductor R&D

Electronic Business

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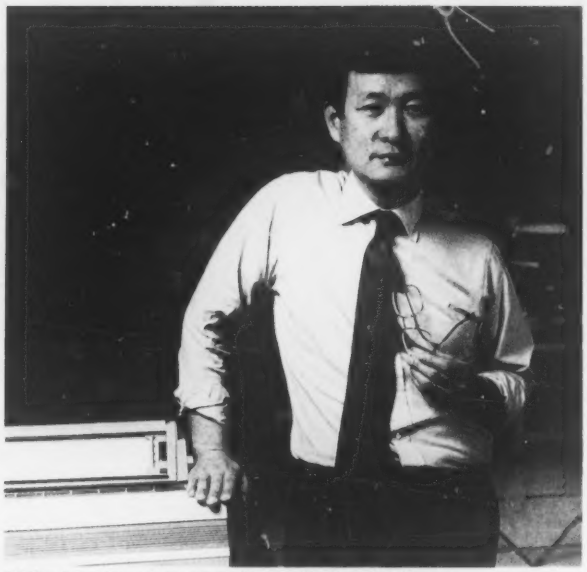

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Hyundai's dilemma mirrors Korea's dilemma

Hyundai has a problem. After investing $600 million in building its high-technology base largely on the innovation of others, the Korean giant is finding it increasingly difficult to access the same U.S. and Japanese sources of information. Unfortunately for Hyundai, this crunch comes at a time when it needs new technology more than ever. South Korea's low-cost labor and currency advantages are rapidly eroding, making it essential for Hyundai to move upmarket from its commodity products: knock-off personal computers and me-too chips.

So Hyundai has launched a massive effort to become more self reliant. In a way, Hyundai's concerns reflect those of Korea. Both are feverishly trying to move from cheap assembly work to more sophisticated R&D and manufacturing — for their survival. Senior editor Alden Hayashi traveled to Korea to explore these issues. Read his observations in this issue's cover story.

Assistant editor John McCreadie

Laptop evolution

Laptop technology is changing fast. Even as industry analysts struggle to define the elements that qualify a computer to be called a laptop, many of those elements are being altered in redesigned products. Indeed, a new laptop can be obsolete within six months. Overwhelmed vendors are fighting hard to keep up, relying heavily on component makers to provide the latest technology.

Meanwhile, laptop sales are expanding rapidly. U.S. sales tripled in two years to $1.2 billion last year, according to Dataquest Inc. By 1992, worldwide demand could hit $5.9 billion, of which $4.1 billion would be in the United States. So computer and component makers can't afford to be blasé. New ELECTRONIC BUSINESS assistant editor John McCreadie, who joins senior editor Valerie Rice in our San Jose office, takes a look at the opportunities and pitfalls for laptop computer makers in our "Market Perspectives" section.

Another addition to our staff, associate editor Barbara Berkman, explores a related issue: how lithium batteries are rewriting the rules for laptop makers. NEC Corp. is betting big on advanced lithium cells for its new laptop. And some board makers are doing the same. But others wonder if they can achieve the same low-weight payoffs. It's a question that's getting a lot of consideration these days.

BETH KARLIN, managing editor

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Why Cypress and IDT may have a fight on their hands

The market for sub-35 ns SRAMs should grow 44% yearly to $1.2 billion by late 1993. No wonder TI and Hitachi are interested

These are boom times for high-speed SRAM manufacturers.

With spiraling growth rates, high average selling prices and no dearth of customers, manufacturers of fast static RAMs have the world at their feet right now.

But maybe things are going too well. The high-speed SRAM market has long been dominated by a handful of small American companies (and some Japanese companies), which keep one step ahead of the competition by pushing CMOS technology to its limits. Now, as the slower, commodity SRAM market starts to show some price degradation, large companies on both sides of the Pacific are looking around at new market opportunities and finding fast SRAMs.

Companies including Fujitsu Ltd., Mitsubishi Electric Corp., Motorola Inc., National Semiconductor Corp., Texas Instruments Inc., Toshiba Corp. and others are going after the high end of the SRAM business with big guns, and even some new process technologies like BiCMOS. For the first time, smaller American companies are getting a run for their money.

These companies can "be very responsive," notes William McLean, a market watcher with research firm Integrated Circuit Engineering Inc. "But right now the competition is not all that great. It's going to get tougher."

And not just from U.S. contenders. "I think the American companies are going to be surprised at how aggressively Japanese companies begin to pursue the high-speed SRAM market," says one manager for a Japanese chip supplier. "They've seen price erosion in the commodity SRAM and DRAM marketplace, and they are looking for something to replace those margins."

Margins have been very high in the fast portion of the SRAM market. So high, in fact, that companies such as Cypress Semiconductor Inc. and Integrated Device Technology Inc. (IDT) have had record sales and earnings, in no small way attributable to the success —and high prices — of these chips.

Cypress' SRAM marketing manager Tom North: "The most significant change in the SRAM market today is that there is a market now in PCs and workstations"

Liane Enkelis

Setting the stage

And those high margins have set the stage for market growth figures little short of phenomenal in the fast (70 nanoseconds and less) and very fast (35 nanoseconds and below) portions of the market.

The total worldwide SRAM market in 1988 hit $1.7 billion, says Dataquest Inc., and should grow to $2.8 billion by 1992. But those figures mask the real areas of growth — and megabucks opportunity — to be found in the fast and very fast portion of the static RAM marketplace.

Market research firm ICE says the market for very fast SRAMs in 1988 was $420 million, but is expected to grow at a 44% compound annual growth rate over the next five years, hitting $1.2 billion by the end of 1993.

Fueling the growth in this market segment are two very unrelated occurrences: the shortage of 1-megabit DRAMs and the advent of 32-bit high-performance microprocessors.

For some two years now, the 1Mb DRAM shortage has drawn management attention and dollars away from SRAMs. This has caused a shortage of commodity SRAMs in some areas, according to analysts, because fab lines have been dedicated to intensive DRAM production. The SRAM market is also only one-third the size of the DRAM market, according to ICE, making it inherently less visible to management.

But now that the DRAM crunch is easing, the SRAM market numbers

are looking very appealing. And large companies are rising to the bait.

Another thing tempting large companies is volume. This volume is in both personal computers and workstations, two very large market segments that have been historically out of reach of the average SRAM maker.

Thanks to hot new microprocessors that demand fast cache memories, SRAMs have found a niche —a big niche — in workstations and high-end personal computers. And that niche will spell m-o-n-e-y in the future.

Of the $420 million sold in very fast SRAMs in 1988, $95 million, or almost 25%, went into workstations; $85 million into supercomputers; $75 million into high-speed instrumentation; $100 million into the military; with the remainder going into an "other" category, which includes telecommunications and personal computers, according to ICE.

Workstations are big drivers in this market today, and small American companies, as well as large ones, are going to go aggressively after this market share.

"The most significant change in the SRAM market today is that there is a market now in PCs and workstations," says Cypress' SRAM marketing manager Tom North. But North cautions that the "PC business is a two-edged sword," and notes that Cypress has no more than 10% of its business in the PC arena right now.

Cypress' acknowledged main competitor, IDT, also has a strong concentration in the PC arena, according to Robert Cushman, SRAM business unit manager.

Both North and Cushman agree that the biggest challenge facing them is keeping ahead in the new product wars. One solution both companies appear to have adopted is the so-called "specialty memories," or SRAMs which are closely coupled to a particular computer architecture.

"Today there has to be a closer relationship between processor and memory makers," Cushman states categorically. IDT has announced an SRAM designed to work specifically with the MIPS Computer Systems Inc. 3000 RISC chip. Cypress has announced plans for both an Intel Corp. 80386 SRAM, as well as a Sun Microsystems Inc. Sparc SRAM.

SRAMs have found a big niche in workstations and high-end PCs

Even Japanese giant Hitachi Ltd. has plans to roll out some SRAMs which will be tailored to specific microprocessors, says Ron Bechtold, product marketing engineer. The memories will likely be targeted at the 80386 and Sparc chips.

"There is definitely a trend to unique 32-bit architectures," according to Bechtold. Vendors need "to look at cost sensitive, customized architectures for specific niches."

The other major challenge to the dominance of small American companies is BiCMOS — a relatively new process that combines the speed of bipolar with the low power and temperature qualities of CMOS. Companies such as Hitachi, Saratoga Semiconductor, National Semiconductor and others are making a major push into the BiCMOS SRAM area, hoping that the hybrid process will have the right stuff for a number of users.

Currently, the market for BiCMOS high-speed SRAMs is relatively small, only 3% to 4% of the $420 million total market, according to ICE. But that number is expected to increase at a compound annual growth rate of 33% over the next five years, growing from $40 million in 1988 to $400 million in 1993.

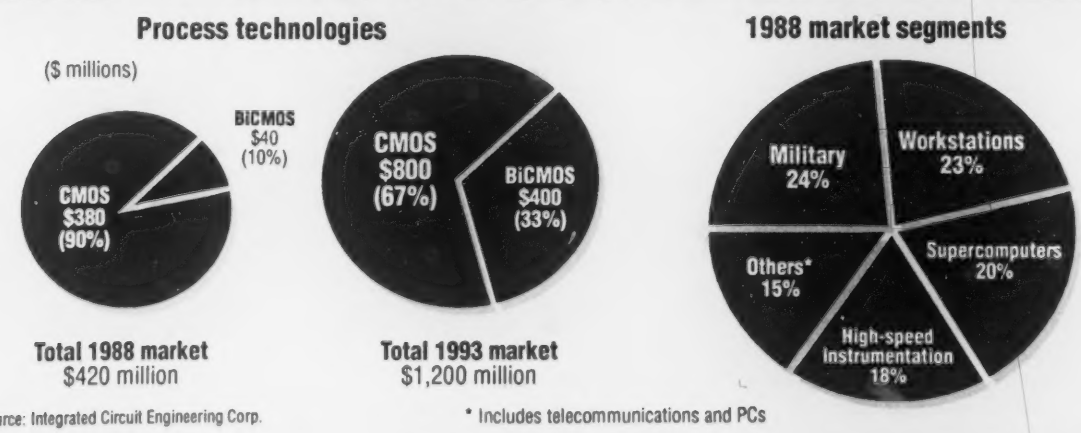
At Hitachi, which has been a big BiCMOS player since the beginning, that figure comes as no surprise. Although Hitachi has a large CMOS SRAM presence as well, it is betting that the BiCMOS product will continue to grow strongly into the 1990s, Bechtold says.

"With BiCMOS, you can get the next generation speed at the current generation price," he says. "It allows an SRAM manufacturer a higher speed part sooner."

But BiCMOS will unlikely displace CMOS over the next five years, analysts agree, noting that at least at the high submicron level (0.8 micron and up), CMOS is still highly competitive.

VALERIE RICE

High-speed SRAMs: Process technologies and market segments



Source: Integrated Circuit Engineering Corp.

* Includes telecommunications and PCs

The Korean conglomerate has not done in chips and PCs what it has done in subcompact cars — and it charges that U.S. and Japanese firms may not let it. Can Hyundai go it alone as its technology sources dry up?

Hyundai's headache

BY ALDEN M. HAYASHI

Hyundai's vice president in charge of semiconductor R&D, Park Kwang O: "The U.S. and Japan want to stomp us out"

Ray Cranbourne/Black Star

Call it your basic "stuck between a rock and a hard place" bind, Korean style.

First, the "rock." The Hyundai Group, one of South Korea's four *chaebol*, or industrial conglomerates, has so far gambled more than $600 million in the global high-tech market. After a slow start, the company finally looked as if it had made some progress last year when officials were expecting meager profits after losing money for the past five years.

But Hyundai, which has forged alliances with American giants such as Texas Instruments Inc., barely has time to celebrate. Company executives — who acknowledge that South Korea's low-cost labor and currency advantages are rapidly eroding vis à vis the country's Asian neighbors — cite the need to move quickly upmarket from Hyundai's bread-and-butter base in commodity products: knock-off PCs and me-too chips. But that trek upmarket will only be possible through continued access to state-of-the-art technology.

Which brings us to the "hard place." Just as Hyundai achieves electronics prominence based on the innovation of others, U.S. and Japanese competitors are beginning to block the flow of technology to the Korean company. Already, Intel Corp. has engaged the Korean conglomerate in a nasty lawsuit charging alleged intellectual property infringements.

Squeezed on both fronts, Hyundai is trying to develop its own technology by pumping up R&D budgets. Engineering staffs have increased dramatically and a new multimillion dollar semiconductor lab is under construction. Hyundai has also entered into various research consortiums as the company scrambles to sign technology-exchange agreements in the sectors it has chosen to compete in: ICs, personal computers, minicomputers, peripherals and telecommunications equipment. And the shipbuilder, automaker and construction-engineering supremo has declared as its goal membership in the world's top 10 chip makers' club. But whether this flurry of activity helps Hyundai achieve in electronics what it has excelled at in cars is still in question.

The $600 million high-tech dilemma reflects concerns not only at Hyundai but at sister *chaebol* like Samsung and Lucky Goldstar, despite their strong track records in consumer electronics. Indeed, it has broad implications for aspiring electronics powerhouses throughout the Far East. However, as Hyundai prepares to take a tougher line in dealmaking, its problems prompt the need for a reexamination by United States and Japanese electronics companies of the nature of their joint

ventures with other Far East partners.

One thing's for sure: Hyundai sorely wants a place in the global electronics limelight. Just five years ago, the $18 billion multinational corporation — faced with a decline in its mainstay shipbuilding and construction businesses — decided to gamble on the fast-growing electronics market. The ante, apparently, was no object. In semiconductors alone, the company spent $345 million on a pair of fabs. A new $350 million manufacturing facility, including an R&D lab, is currently under construction.

Hyundai's electronics gamble — culminating in the creation of Hyundai Electronics Industries Company Ltd. in 1983 — was particularly risky at the time because, prior to then, the company knew virtually nothing about high tech. In contrast, Korea's Samsung Electronics and Lucky Goldstar both had consumer electronics experience before their forays into the semiconductor and computer markets. Still, Hyundai's come-from-nowhere success in automobiles should make competitors think twice before discounting the company's high-tech aspirations.

After a sluggish start in personal computers and a near disastrous one in chips, Hyundai finally looked like it had a winning hand last year. If all goes well as the final numbers are tallied, the company will have made $10 million on high-tech sales of roughly $700 million, according to a company forecast. The year before, Hyundai Electronics lost $12 million on sales of $320 million.

In semiconductors, the company's sales should top $400 million this year, up from about $250 million in 1988, according to Park Kwang O, Hyundai's vice president in charge of semiconductor R&D. And the company this year should export $1 billion of electronics products. In 1988, Hyundai was the 10th largest vendor of low-end PCs in the United States. The company that year sold 62,400 such machines based on Intel's 8086/88 microprocessors.

Hyundai execs always ask why Korea is being forced to pay for Japan's past sins

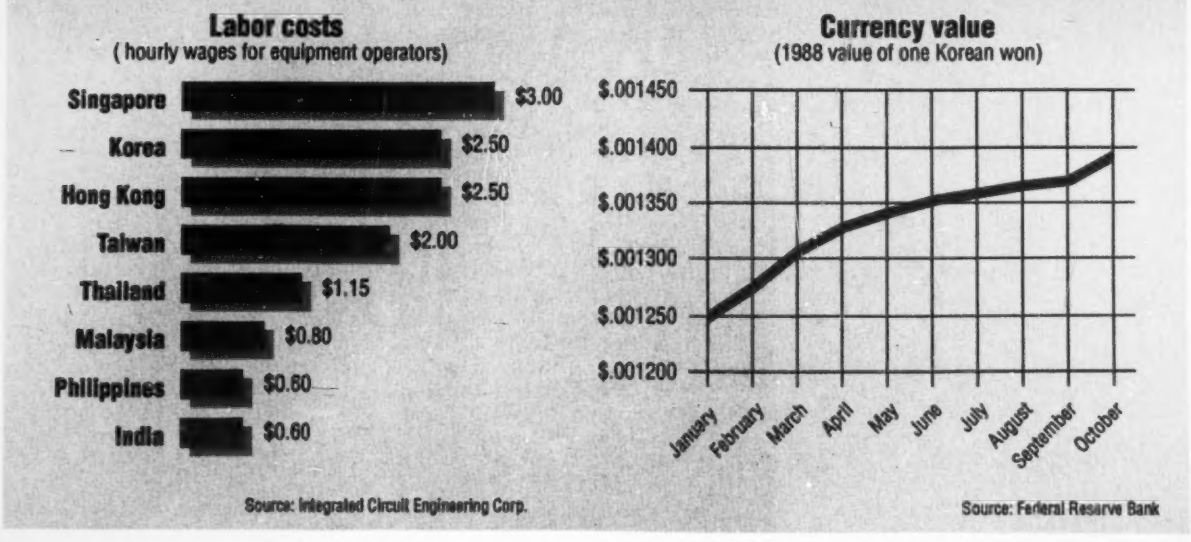
If Hyundai Electronics stays on track, officials say the 11,000-employee subsidiary will go public in 1992. (Currently, the entire Hyundai Group is privately held, but the conglomerate has plans to make public many of its subsidiaries over the next several years.)

The success of Hyundai Electronics, however, has so far been a result of the company's low-cost labor and currency advantages. In the semiconductor field, half the company's business is foundry work for others. In computers, Hyundai makes PC clones and peripherals such as monitors, printers and modems for OEM companies like Commodore Business Machines Inc., Digital Equipment Corp., IBM and Xerox Corp. Hyundai also makes Big Blue PCs for the Korean market.

In a simplified way, Hyundai is a microcosm of Korea. Both company and country are feverishly trying to lessen their dependence on sunset industries in favor of sunrise ones. During an hour-long interview, Choo Hoon, the executive vice president of Hyundai Electronics' information systems division, presented a tidy summary of Korea's predicament. From memory, he recited some daunting statistics: Thailand has a population 20% greater than that of South Korea. Also, Thailand's land mass is five times larger. And, perhaps most importantly, labor costs there are a fraction of Korea's. Furthermore, for the People's Republic of China, the figures are even more skewed against Korea, says Choo.

Recent events have only made the situation worse. Throughout last year, the Korean won appreciated at a frightening rate. From January to

South Korea is losing its low-cost labor and currency advantages



October, the currency had risen by more than 10%, making manufacturing costs that much higher in the country. Consequently, Choo concludes, "If we continue to do just assembly work, we cannot survive." Executives at Samsung and Lucky Goldstar are reportedly worried about precisely the same issues.

The kindness of strangers

It would be an understatement to say that Hyundai's progress in electronics has depended upon the kindness of strangers. The company's personal computers are IBM clones. The architecture and software of its 32-bit minicomputers come from Tolerant Systems Inc. of San Jose, the floppy disk drive technology from Fujitsu Ltd. and printer know-how from Canon Inc.

In semiconductors, the company bought electrically erasable programmable logic device (EEPLD) technology from a company it helped finance: International CMOS Technology Inc. (ICT) of San Jose. SRAM designs are from MOS Electronics Corp. (Mosel), also of San Jose; ASIC design software from LSI Logic Corp. of Milpitas, Calif; and Hyundai's DRAMs are thanks to, not one, but three companies: Inmos Corp., Texas Instruments Inc. and Vitelic Corp.

A lesson in patience

Hyundai's history in DRAMs could well serve the company as a valuable lesson in patience. Several years ago, Hyundai had hoped to learn the fundamentals of DRAM manufacturing from Inmos, but the agreement subsequently crumbled before production had even started. Both companies later reached an out-of-court settlement whose details have remained private.

However, a contract with Vitelic followed in 1985 but the project reportedly fell a year behind schedule because of Hyundai's inexperience. At the time, Vitelic president Alex Au quoted: "The manufacturing problems are tremendous."

In ICs alone, Hyundai increased its R&D staff from 160 in 1987 to 250 last year

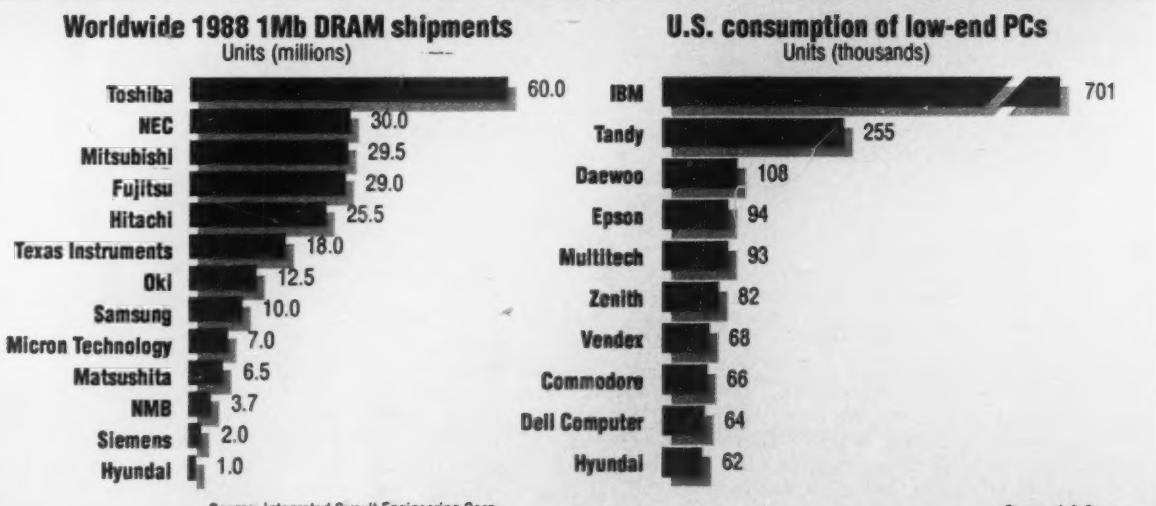
Actually, it took a team of TI engineers most of 1987 to get Hyundai's manufacturing up to snuff. In exchange for the private tutoring, Hyundai has supplied Texas Instruments with foundry services. "With Hyundai's new fab, they should be very competitive with the Japanese," according to Bruce Campbell, vice president of marketing for Mosel, which also subcontracts out its manufacturing to the Korean company.

Clearly, the TI relationship has benefited Hyundai and Park says he is intent on maintaining the partnership. But whether the feeling is mutual is entirely a different story. Indeed, TI appears to harbor no particular feelings of loyalty toward its Korean comrade, especially given Hyundai's recent emergence as a semiconductor competitor. In the past, more than 80% of Hyundai's total production used to be foundry work as the company learned from others the ins and outs of semiconductor manufacturing. But Hyundai has not been content just making chips for others to sell. Park makes no bones about his all-consuming goal: make it onto the list of top 10 worldwide semiconductor companies within a decade. Consequently, Hyundai's foundry work has fallen to 50% of production, and Park says his goal is to have the figure drop further, to below the 30% mark.

Such brashness from the new kid in town worries TI chairman Jerry Junkins. When asked who TI would license its next-generation DRAM technology to, Junkins was unusually curt. "It may, or may not, be Hyundai," he replied.

At any rate, Junkins says his strategy is to stay one technological step ahead of the foundries. To that end, Junkins says TI will only license its

Hyundai can't count itself in the big chip and PC leagues yet



"If we continue to do just assembly work, we cannot survive," says Choo Hoon, executive vice president of Hyundai Electronics' information-systems division

Ray Cranbourne/Black Star

1-megabit design when the company is more than ready to move on to the 4Mb DRAM level. Hyundai is currently making TI's 256-kilobit DRAMs.

Junkins' strategy is shared by others. Hyundai's Choo complains, "Canon let us have their impact printer technology only after they had moved to laser technology. I tried several times to get Canon's laser printer technology, but in all cases, they denied it."

Other sources of technology may also be drying up. Five years ago, Hyundai invested in ICT, a San Jose chip start-up. Eventually, the Korean company received ICT's EEPLD design in a cash-for-technology deal. Today, Hyundai retains just a minority stake in the firm and ICT president and founder Drew Osterman says he does not expect any further technology exchanges between the two companies.

A spat with Intel

Indeed, the mood in the United States has taken a sharp turn away from the laissez-faire atmosphere of the past. Last November, a judge for the International Trade Commission ruled against Hyundai in a patent spat involving Intel's EPROM technology. If Intel's patent infringement claims are upheld, the offending Hyundai chips could be barred from entry into the United States.

And companies are demanding more for sharing their intellectual property. Although Hyundai freely knocked off IBM's personal computers in the past, Choo says that Big Blue has become extremely protective regarding its new generation of Personal System/2 PCs. "We're talking with IBM but nobody knows what will happen. They're asking too much for patent royalties," he asserts.

Hyundai officials have noticed the mood swing in the United States. Two years ago, Park brushed off the growing number of intellectual property lawsuits as a "Mickey Mouse game." Recently, he acknowledged that continued access to technology has become one of Hyundai's most critical problems.

In many respects, the United States' tough stance puzzles the Koreans. Hyundai executives repeatedly question why Korea is being forced to pay for Japan's past sins. It is this feeling of persecution coupled with the company's severe dependence on foreign technology that has top management teetering on the verge of paranoia. "The U.S. and Japan want to stomp us out," cries Park. "There's no way we can survive being dependent on outside technology."

So, Hyundai is doing the logical thing: trying to develop the necessary technology in house. The company spent roughly 25% of its $250 million in semiconductor sales on R&D last year, according to Park. "You have to spend money to make money," he says.

And spend money Hyundai has. For semiconductors alone, the company increased its R&D staff to 250 people last year from 160 people in 1987. This year, Park plans to increase the number to 400. Hyundai will need the additional personnel for the company's new $350 million fab, scheduled for completion during the third quarter this year. In the fab, one of the 6-inch wafer lines will be reserved for production; the other for R&D. The fab's production capacity, when fully operational, will be 40,000 6-inch wafers a month.

In computers, the story's the same. "My president ordered me to not increase our direct labor. But there are no limitations placed on R&D labor," says Choo. In his division, R&D personnel will surge from 200 people last year to roughly 300 this year. The company is particularly keen on software development; roughly 30% of its R&D staff were software engineers last year.

Almost to the point of desperation, Hyundai has been trying nearly everything to stoke the company's technological creativity. Three engineers whose IQs each exceeded 150 were hired from the Korean Advanced Institute for Science and Technology. The engineers were placed in a think tank and management has given them total freedom. "They get to work on whatever they want. I think one is working on image processing," says Choo.

However, some progress has been made. Hyundai says the 1Mb DRAM scheduled for production in its new fab is its own design based on Vitelic's technology. At the same time, the next-generation 4Mb DRAM, which Hyundai plans to offer engineering samples of later this year, will also be the company's own design, according to what Park claims. And Hyundai expects to be among the first to develop a 16Mb DRAM by 1992. "From older technologies we can develop some very innovative

products," according to Choo.

Can Hyundai do high-tech R&D? The evidence to date has not been encouraging. After opening a large semiconductor R&D center and wafer fab in Santa Clara in 1984, the company abruptly closed shop there a year later. The building and land were sold to Siemens; the equipment and a handful of the personnel were moved to Ichon; and the company took an estimated $20 million loss. Hyundai's mistake was in investing too much too soon, says Park. "Upper management got impatient when the output for the facility was not immediately proportional to the input."

One thing that the California R&D center would have provided Hyundai with is engineering talent. Silicon Valley is littered with experienced electrical engineers; Seoul is not. To broaden its pickings, Hyundai revised its policy in Korea of only hiring Korean nationals. Still, Park admits that although Hyundai has been trying to attract qualified engineers from the United States, few have wanted to make the move to the company's industrial park in Ichon, a farming village about an hour's drive from Seoul.

Hyundai's shortage of technical brainpower is compounded by the company's lack of experience. "Many of our semiconductor people have Ph.D.s, but not one of them can design a simple circuit," laments Choo. "All we can do is take somebody else's mask set and produce the chip." Park acknowledges that the average age of his engineers is below 30. "But," he adds, "they work twice as hard as other engineers."

Hyundai expects to be among the first to develop a 16Mb DRAM by 1992

Even *with* the appropriate personnel, Hyundai's midstream efforts might still land the company in court. Analysts claim the company may have just too much catching up to do. "They're going to find it very difficult to develop their own technology at this level without stepping on somebody's toes," notes William J. McClean, analyst for market researcher Integrated Circuit Engineering Corp. of Scottsdale, Ariz.

Where possible, Hyundai is borrowing any outside technology which is readily accessible. In the information processing arena, it should come as no surprise that the company settled on Unix, which AT&T licenses for a nominal fee, as the operating system for its superminicomputers. By doing so, Hyundai is hoping to tap into the vast public library of Unix software. And, according to Choo, the company may join the so-called "Gang of Nine," the group of nine computer manufacturers — including Compaq Computer Corp., Tandy Corp. and Zenith Data Systems Corp. — whose charter is the development of a PC bus alternative to IBM's closely guarded Micro Channel technology.

In addition, the Koreans have adopted a "united we stand" strategy. A group of companies, including

Semiconductor technology alliances held by Hyundai electronics

Companies in alliance (technology)

Texas Instruments Japan (256K DRAMs)
TI to technically assist Hyundai's mass production of 256K DRAMs. Hyundai will then sell DRAMs to TI on an OEM basis. **Date announced:** July 1988.

Daewoo, Korea Electronics and Samsung (32-bit ICs)
Joint R&D program to develop 32-bit PC microprocessors and microcontrollers through December 1990. **Date announced:** 1988.

Korea Electronics and Samsung (transistors)
Joint R&D program to develop high-power transistors through December 1990. **Date announced:** 1988.

Intel (EPROM and DRAM patents)
Intel charges Hyundai and U.S. subsidiary with EPROM and DRAM patent infringement. **Date announced:** September 1987.

Mosel (CMOS products)
Hyundai to act as a foundry for Mosel's CMOS products. **Date announced:** February 1986.

Electronics Technology Research Institute, Goldstar and Samsung (Submicron processes)
Joint R&D program to develop submicron technology processes and products. **Date announced:** 1986.

Inmos (256K DRAMs)
Joint development of 256K DRAMs from Inmos technology and alternate sourcing agreement. **Date announced:** February 1985.

Ricoh (Silicon wafers)
Ricoh to supply foundry services to Hyundai. **Date announced:** 1985.

Vitelic (DRAMs, SRAMs in CMOS)
Exchange of Vitelic's technology for Hyundai's foundry. **Date announced:** 1985.

Inmos (CMOS memories)
Date announced: 1984.

Western Design Center (CMOS microprocessors)
Hyundai to make and market WDC's 8-bit and 16-bit CMOS versions of 6502 microprocessor. **Date announced:** 1984.

International CMOS Technology (CMOS EEPROMs)
Joint development and marketing of 1K CMOS EEPROM. The firms to develop three other chips each that both will market. Hyundai to provide foundry services. Hyundai has an equity investment in ICT. **Date announced:** 1983.

Source: Regis McKenna Inc.

Hyundai, have banded together to develop high-density memory chips. Hyundai is also involved with some of the other Korean *chaebol* in another project to develop a parallel processing superminicomputer using the Unix operating system.

So far, the memory chip consortium has been a success, claims J.H. Son, manager of the Seoul office of market researcher Dataquest Inc. According to Son, the group has already developed a manufacturable 4Mb DRAM. Another $263 million has been allocated to develop a 16Mb DRAM by March 1991 and a 64Mb DRAM two years later. Sixty percent of the funding comes from Daewoo, Goldstar, Hyundai and Samsung, with the remainder financed by the government.

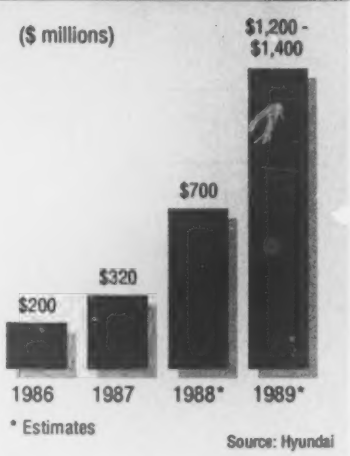
Hyundai, however, has not given up on partnerships with foreigners. The company was recently negotiating with Seagate Technology, the ailing disk drive king of Scotts Valley, Calif. A joint venture between the two companies might make sense; at one point last year, Hyundai was buying 7,000 hard disk drives a month from Seagate. Previously, the Korean company was able to obtain floppy disk drive technology from Fujitsu.

Hyundai is also counting on global partnerships to diversify its semiconductor business. DRAMs currently make up roughly 70% of Hyundai's total chip sales. Last year, the company sold more than $180 million of DRAMs, accounting for approximately 3.5% of the total worldwide market. Park, who compares Hyundai's semiconductor division to a table with uneven legs, says the company needs to get quickly into other markets such as logic chips and ASICs. Indeed, the next DRAM industry downturn — which might occur as soon as late this year — could propel Hyundai's DRAM business back into the black, says Dataquest's Son.

In order to branch out, Hyundai will have to enter into several winning partnerships. But the company is tired of playing the role of the needy relative seeking a handout. In the future, Hyundai will only enter into mutually dependent partnerships as opposed to cash-for-technology deals, according to what Park says. That way, Hyundai will be less vulnerable to being jilted, he asserts.

In its semiconductor hope chest, Hyundai boasts three belongings: a somewhat mature manufacturing process, a budding memory chip business and lots of cash. Such a dowry might interest a European suitor like N.V. Philips or SGS-Thomson, speculates ICE's McClean. Also, a company like National Semiconductor Corp. could use Hyundai to springboard back into the DRAM business.

Hyundai's electronics sales



One thing Hyundai will not do to solve its technology woes is buy another company, states Park. In spite of the current spate of hostile takeover attempts in the U.S. electronics industry, Park contends such actions court disaster. There exists no guarantee, he says, that a high-tech company's greatest asset — its engineers — would remain after being acquired. "We don't want to end up holding an empty bag."

It's an understatement to say that Hyundai's progress in electronics has depended upon the kindness of strangers

Beg, borrow or . . .

Ultimately, Hyundai's success in the electronics market will depend on how well the company can beg, borrow, or — the gods of high-tech permitting — invent by itself the necessary technology. One thing's for sure: such knowledge does not come cheap — not anymore.

Whether Hyundai's corporate elite fully realize this is unknown. In fact, the company's detractors claim Hyundai's top brass still lack a complete understanding of the electronics industry. Critics claim Hyundai's founder and chairman Chung Ju Yung oversees the conglomerate's 25 subsidiaries like a feudal lord guarding his fiefdoms. In charge of Hyundai Electronics is Chung Mong Hun, Chung Ju Yung's son. Before assuming the top post at Hyundai Electronics, the then 35-year-old Chung had virtually no experience in high tech.

On their part, Hyundai officials do not see their electronics foray as particularly risky. In fact, they say they are willing to do whatever it takes to succeed. To that end, the company recently announced it would invest an additional $1.15 billion in electronics during the next five years. As the anecdote goes, when one executive was asked why Hyundai was gambling so much in an unfamiliar market, he replied, "We don't think it's risky. After all, we do construction in the Middle East."

Nonetheless, Hyundai's long-term commitment to the electronics market remains suspect. Lodged in many people's minds are memories of the company's abrupt pullout of Santa Clara. According to one report, Hyundai workers there arrived at work one day to find the gates locked and a notice that final paychecks were in the mail. Not surprisingly, many former employees and a few current ones have repeatedly complained of the impatience of Hyundai's top management. "There's a lot of resentment in the company about that," notes George Long, research analyst with investment brokerage W.I. Carr Ltd.'s Seoul office.

As the company's high-tech investments tally toward the $1 billion mark, Hyundai's employees — particularly chairman Chung Ju Yung — must be wondering just how long and how much money it takes to play the high-tech game. The answer may be supplied by the Goldstar Co., which last September announced plans to build a new semiconductor fab in Chongju, Korea. The facility's completion date: 1996. Its price tag: $2.22 billion. □

Does military R&D stimulate commerce or the pork barrel?

Pentagon officials insist massive defense spending has a hidden reward — lucrative and numerous commercial spin-offs. Others aren't so sure

BY MICHAEL R. LEIBOWITZ

Commercial spin-offs. They're mysterious and fuzzy and defy all attempts at measurement. And their vagueness makes them the ideal riposte for policy debates. The Pentagon cites potential spin-offs to justify expensive military programs. Legislators use the specter of spin-offs to argue that the U.S. doesn't need to fund efforts like Japan's MITI. Even the Japanese talk of our spin-offs to claim that the U.S., in fact, also provides substantial government support to its electronics and computer industries.

Those who use the spin-off argument cite history. They recall that the U.S. Department of Defense was the prime support of such technologies as computers and transistors in the 1950s, integrated circuits in the 1960s, and networking in the 1970s. Commercial spin-offs, proponents argue, are the hidden reward for spending massive sums on defense R&D.

Using this argument, the 1980s should be the golden age of military-inspired electronics and computer spin-offs. Since the defense buildup began in 1982, a record of more than $12 billion has been spent on electronics-related R&D for programs ranging from very high-speed integrated circuits (VHSIC) to the Strategic Defense Initiative.

But, many are now asking, where are the spin-offs? "In general, they have declined," says Kenneth Flamm, an economist at the Brookings Institution, a nonprofit Washington research group. Flamm, along with a growing number of critics, contends that the notion of lucrative commercial outgrowth of the 1980s defense R&D buildup is little more than a myth.

For example, when the three current VHSIC Phase II contractors — Honeywell Inc., IBM and TRW Inc. — were asked about commercial spin-offs, none could come up with anything significant. Robert Estrada, manager of IBM's VHSIC program in Manassas, Va., says that while senior executives view the program as being important, "there might be some disagreement with the commercial side as to how much they've benefitted." The $1 billion, 10-year effort is aimed at achieving 0.5-micron radiation hardened ICs.

Ardent Computer's Gordon Bell, father of the minicomputer, calls VHSIC "a big pork barrel business"

Cindy Charles

Pork barrel

Gordon Bell, R&D vice president at Ardent Computer Corp. and father of the minicomputer, puts his opinion about VHSIC a bit stronger: "[VHSIC's purpose] was to bring a bunch of old-line, miserable semiconductor guys up to the state of the art of commercial. It's a big pork barrel business." Agrees Brookings' Flamm: "It's been the antithesis of how to run a program to get spin-offs."

Flamm and others point to several key policy changes that have helped stifle commercial spin-offs in the 1980s. Prominent among these is a shift away from basic research toward development of specific military technologies — technologies that are expensive and have little in common with the needs of the commercial marketplace. Funding has also shifted from universities to defense contractors, where the ideas get trapped with no way of reaching the commercial market.

Even the Defense Advanced Re-

search Projects Agency (DARPA), the arm of the Defense Department widely credited as contributing the most to the commercial base during the past 25 years, has seen its research agenda politicized in the 1980s, critics charge. This means less return from projects such as DARPA's Strategic Computing Program, the $600 million effort designed to promote the most promising computing technologies.

The diminishing payout in commercial spin-offs comes as a surprise to anyone familiar with Defense's history as a booster to the civilian computer and electronics industries. Since the dawn of the computer age, Defense has played the role as key funder and early patron of electronics' most important new technologies.

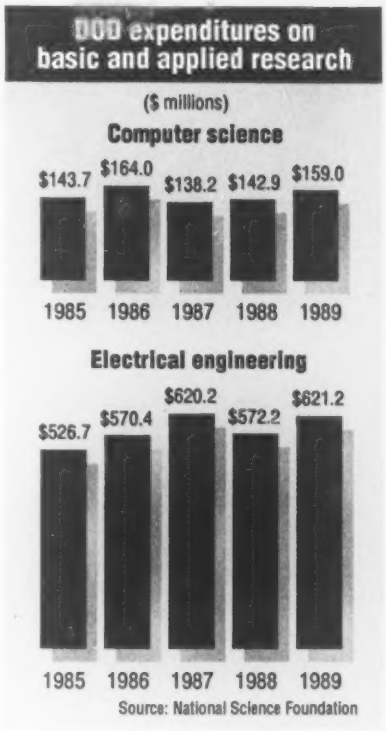
Birth of the computer

Who would pay money for a computer that had 18,000 vacuum tubes and failed once a day on average? Only the military. Defense paid for development of the ENIAC and provided a market for many of the computers developed in the 1940s and early 1950s. It wasn't until the late 1950s that a significant commercial market for these machines developed.

Likewise, the military and NASA snatched up the first crude integrated circuits at $100 a pop in the early 1960s, when no one else would. DARPA paid for the world's first packet switching network in the 1970s, advancing a technology that has become the staple of datacommunications.

This decade's spin-off examples include expert systems, which derived from rule-base programming work sponsored by DARPA in the late 1970s. And you can thank DARPA for Unix-based workstations, as well. Sun Microsystems Inc.'s first Unix-based technical workstations in 1982 spun from a DARPA-sponosored program at Stanford University and Berkeley 4.2 developed at the University of California at Berkeley.

"The field of computer science, pure and simple, was invented and fueled by DARPA," says Dan Dimancescu, technology policy consultant and author of several books on R&D policy. But several changes have occurred since 1982 to limit the potential for commercial spin-offs



from defense R&D. Perhaps the most dramatic, according to economist Flamm, is the fact that almost none of the new funds spent on military R&D have gone to research. Virtually all have gone to develop specific military applications, dominated, of course, by SDI. Military expenditure for basic research, says Flamm, "has, in fact, declined somewhat from its 1970s levels."

The short shrift that research has gotten is significant because, dollar for dollar, research is generally considered to be a far more fruitful source of spin-offs. Military development concentrates on accomplishing specialized engineering feats — exotic advances that have little usefulness in the commercial market. Yet, research focuses on making progress in fundamental, generic technologies that can also solve problems in the commercial market.

Most of those commercial spin-offs cited earlier resulted from research funding. Occasionally however, development funding does benefit the commercial market by providing an early market for an emerging technology.

The VHSIC scenario is different, however. One of the reasons for the dearth of VHSIC spin-offs is the program's goal of radiation-hardness, which isn't an important consideration in most nondefense applications. Another problem is that, for the military, cost is no object. Instead of trying to refine optical lithographic techniques to acheive the 0.5-micron device geometries, for example, contractors are "brute forcing" it with expensive E-beam and X-ray lithography. The task of pushing less-expensive optical lithography — into the submicron range is left to the commercial chip makers.

With the shift from research to development has come a corresponding shift from an emphasis on university laboratory work to an emphasis on large defense contractors. And with this comes secrecy, the bane of any attempts to commercially transfer technology. "To get broad utilization of R&D, it has to be published," says Robert Noyce, coinventor of the integrated circuit and chief executive of the Sematech semiconductor consortium. Today, he says, "less and less [VHSIC and other military R&D] is."

With research held captive inside the contractor's walls, one hope is that the defense contractor itself might try to commercialize the technology. Yet, many of the defense contractors, companies such as General Dynamics Corp. and Martin Marietta Corp., lack the commercial divisions that could bring the spin-off to market.

And in the cases where research information is published by the defense contractors, the details are kept under wraps, according to Lou Thomasetta, CEO of gallium-arsenide chip maker Vitesse Semiconductor Corp., in Camarillo, Calif.

Even if a company has a commercial side to it, the chances for spin-offs are slim, according to Kent Black, president of Rockwell International's electronics operation. Although Rockwell has a large commercial operation, accounting for 40% of its electronics revenue, transferring technology between military and commercial is "very difficult," says Black, and occurs infrequently.

Perhaps the only route for defense-sponsored R&D to flow out to the commercial market is by employees quitting and starting up their own companies. That has been the route for the merchant GaAs IC business,

which started up when Rockwell employees quit to establish the first merchant GaAs chip maker, GigaBit Logic Inc., in 1981. But it's a slow and inefficient process, says Thomasetta, a former Rockwell scientist.

DARPA compromised

As powerful as the defense lobbies are, there once was an agency — DARPA — that could resist all the politics and hand out funds to best stimulate research. But critics point to DARPA's Strategic Computing Program as positive proof that even the nation's premier sponsor of R&D has been compromised in the 1980s.

SCP's stated goal was to advance key information technologies important to the country's economic as well as national security. The plan was to disburse a total of $1 billion to turbocharge U.S. research in technologies such as artificial intelligence, parallel computing and microelectronics.

But unlike prior DARPA programs, in which all funds were earmarked for research, SCP had specific military applications to tackle. The systems, ranging from a "pilot's associate" to a "battle management system" satisfied critics in Defense who argued that DARPA research had no relevance to military systems. But it also sopped up lots of money.

Approximately 25% of the SCP budget goes to developing these specific applications. DARPA asserts that the systems serve to focus the research done in SCP toward generic applications. But critics charge that the applications are too defense oriented with little potential payoff to the civilian sector.

According to economist Flamm, SCP is not an "R," or research, program, as past DARPA efforts were. "It's an R&D program. And it's typical of the basic shift [within DOD] toward development." Although it will result in spin-offs, the trend toward development will dampen the potential, he says. "DARPA's been politicized," says consultant Dimancescu.

But for those who complain about the lack of spin-offs in the 1980s, the biggest boondoggle for spin-offs: the Strategic Defense Initiative. It is perhaps the most controversial defense project ever conceived, and it also draws a large share of military R&D funding today — the electronics and computer R&D represent an estimated 30% of the $15 billion spent on SDI between 1983 and this year. But for those who track spin-offs, SDI is particularly alarming because it is being sold to a wary Congress and public on its spin-off potential.

SDI "will so stimulate the national economy that it will pay for itself," said Lt. Gen. James Abrahamson, SDI's director. Critics contend that this is little more than wishful thinking. All the problems of applications oriented, contractor-performed work are present in SDI, they say — only magnified several hundred times. In electronics and computers, the technologies are more specialized and exotic than ever, boding poorly for commercial applications, claim critics.

Sematech chairman Robert Noyce worries that technology gets trapped inside defense contractors

SDI's supporters, from contractors to Defense officials, say that one of the big spin-offs of SDI will relate to highly parallel systems, used to quickly process the information coming from giant arrays of sensors. They talk about other spin-offs in such areas as higher density, higher speed gallium arsenide ICs and semiconductors that can switch hundreds or thousands of amps of current.

Who cares?

But the commercial world cannot use these developments, critics claim. There's no great need in commerce for highly parallel architectures that can run simple, repetitive algorithms very fast in real-time applications, according to David Parnas, professor of computer science at Queen's University, Kingston, Ontario, and a former member of SDI's Eastport advisory panel. Instead, the need is for parallel systems that can run multiple complex algorithms.

GaAs R&D is likely to proceed without concern for cost, critics charge, while the commercial GaAs market remains fixated on keeping expenses down. And semiconductors that can switch large amounts of current might be useful, but how much are these going to cost?

In software, SDI is trying to do things too quickly with too much money, adds Parnas. "They're getting old ideas, and they're getting bad ideas." SDI, says Parnas, is funding solutions to SDI's software problems that are based on people's promises, rather than critically evaluating whether those approaches will work. Charges Parnas: "The program is being managed by people who don't know very much about the field."

The SDI organization (SDIO) is attempting to disseminate information about SDI technology, to answer critics' charges that research is cloaked in secrecy. The SDIO spent over $1 million to establish a database containing unclassified information on SDI technologies — their Technology Applications Information System — accessible by anyone passing a minimal clearance. But critics charge that the database contains useless information, watered down by the declassification process.

This all leads to one question: Can anything be done to make military R&D result in more spin-offs? Suggestions range from shifting military R&D back toward research to reforming procurement procedures and eliminating the pork barrel. But any changes will take a long time. Working against any changes, says policy consultant Dimancescu, is "the inertia of the system."

Others say that, frankly, it's folly to expect to see commercially important spin-offs from revised military R&D procedures. "If we want to promote the commerce we will do that which has the highest leverage," says Sematech's Noyce, referring to commercial initiatives such as Sematech. If "you doctor up programs that have a different purpose, then you'll fail in both purposes."

Meanwhile — everyone still talks about spin-offs. □

Why technology change is the curse of the laptop class

Six months is enough to obsolete a laptop these days. Pity the vendors as they try to keep up, using everything from upgrades to hiring blitzes

BY JOHN McCREADIE

While industry analysts mull over the arduous task of defining what criteria qualify a computer to be called a laptop, sales of the battery-powered, briefcase-like computers continue to soar. Manufacturers, however, are not as worried about defining size and weight parameters as they are with how to keep up with the rocket-pace of new laptop technologies.

Competition is wolfish, as manufacturers attempt to keep up with the speed of today's booming market, fearful that some newer, more innovative product will steal away their market position. In a bid to preserve their positioning, most laptop makers are modeling their marketing strategies after the laptop's successful predecessor — the desktop computer. In addition, many vendors are trying to position their newer laptops as an end-all product, hoping to grab some desktop market share.

Tom Martin, vice president for marketing and product development for NEC Home Electronics (U.S.A.): "We absolutely think that the appropriate role of the laptop computer is as people's primary computer"

Marc Serlow

Manufacturers are hoping to gain greater market penetration by expanding current product lines, implementing extensive advertising campaigns and increasing product life cycles. But ultimately, the highest success any laptop player will reach inevitably rests on the availability of the newest component technologies. Laptop makers, however, have differing views on how to achieve this.

Surprisingly, two PC leaders are lagging behind the pack. Both Apple Computer Inc. and IBM, which scored poorly with its portable PC entry some years ago, have returned to the drawing boards to beef up laptops they have been developing because they were not competitive with recent product announcements, say industry watchers.

Breaking into the laptop market is important because it is big and getting bigger. Laptop sales in the United States tripled in two years, making it a $1.2 billion industry last year, according to Dataquest Inc., a San Jose-based market research firm. By 1992, worldwide market sales could hit $5.9 billion, of which $4.1 billion will be in the United States, reports Dataquest.

Most credit today's popularity of laptops to breakthroughs in screen technology. "The laptop market is one place where screen technology has really been a driving force," says Kevin Mankin, director of product development at Zenith Data Systems. Likewise, hard disk drive technology has evolved such that drives now require a minimal amount of power, making them very functional in laptop computers. Here, too, the technology is advancing very fast. Newcomer PrairieTek Corp. is now marketing an unprecedented 2.5-inch rigid disk drive that, if it catches on, could open the way for even smaller, lighter and more powerful portable

machines. But what laptop makers unanimously say they now desire most is a breakthrough in battery technology.

In order to keep up with rapidly changing designs and technologies, manufacturers are scrambling to find ways to gain a competitive edge with their laptop products. "Because the technology is changing so rapidly, it's almost always possible for someone to beat you on a given feature six months after you launch a product," says Tom Martin, vice president for marketing and product development for NEC Home Electronics (U.S.A.) Inc.

Upgrades

Grid Systems Corp. of Mountain View, Calif., which uses its own salesforce to go directly to end users, makes its 286- and 386-based 1500 series models upgradeable in the hopes of increasing the potential product life of its portables. Its 80286-based motherboard can be upgraded to an 80386 and the hard disk drive is changeable, says Bruce Walter, Grid's senior vice president for sales and marketing.

The current market share leader, Zenith, credits its leading-edge success to putting more emphasis on sourcing components from outside vendors than on internal research, says Mankin, highlighting that strategic relationships with suppliers are especially important in gaining access to new developments.

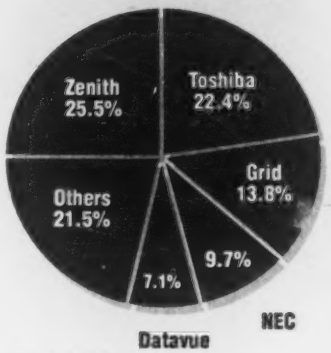
But Toshiba America Inc. disagrees with an outside design integration strategy. The Japanese company, second to Zenith in U.S. market share, is almost entirely vertically integrated and sources out only a few of its laptop components, says Toshiba's director for PC marketing Tom Sherrard.

A few companies, however, admit that the rate of technological advancement is difficult to keep up with. These companies have adopted a different strategy. Take Sanyo Business Systems Corp., for instance. "We're not out to be the cutting edge of technology," says Sanyo's marketing manager Grace Szwagulinski. "We put out a quality product and sell to the niche market." For Sanyo, that niche market includes students and people in small businesses.

Korean conglomerate Samsung Information Systems America Inc., one of the newest players to enter the laptop arena, is, like most manufacturers, distributing laptops through the same channels it established with its PC products. Besides distributing through its usual national and regional distributors, Samsung is going directly to laptop specialty outlets which are slowly springing up around the country, says K.W. Jun, sales and marketing operations director for Samsung.

U.S. laptop market

Share of U.S. unit shipments



Total 1988 market
Units: 723.6 thousand
If-sold value: $1.17 billion

Source: Dataquest Inc.

Because the laptop industry has changed so much in the past two years, manufacturers are using print-media advertising to educate consumers. NEC reports spending $4 million on its current five-month laptop advertising blitz, a substantial jump from the $2 million it invested for the entire year in 1988. Sanyo, which reports monthly increases of 25% in orders for its laptop, has increased laptop advertising by 15% over 1988. Grid is targeting trade magazines with plans to double its current advertising revenue this year.

By 1992, laptops could account for 16% of all PCs sold, up from 7% in 1988

As the marketing focus of the laptop market expands, laptop vendors are also taking aim at a slice of the mainstream desktop market. "We're not talking about just taking share in the laptop market," says NEC's Martin. "We're talking about reconceiving the way computers are used. . . . We absolutely think that the appropriate role of the laptop computer is as people's primary computer."

NEC offers a "Docking Station" that effectively turns its laptops into desktops. Compaq Computer Corp. also features an optional Desktop Expansion Base with its new SLT/286 laptop; the base provides two full-sized standard expansion slots for special tasks such as micro-to-mainframe interfaces. This means all standard peripherals can remain hooked up to the base while the laptop remains easily portable.

Threat to desktops?

Still, the laptop market is far from controlling the personal computing industry. In 1988, only 7% of all personal computers purchased were laptops, says Dataquest. The researcher estimates, however, that by 1992 laptop market share could increase to 16%.

Unless a manufacturer develops all of its own components, vendors need access to volume quantities of newly developed components to stay competitive. Says Lorie Strong, Compaq's director for product marketing, "We are selling our laptop at a rate higher than we can deliver." One reason for this underproduction is the difficulty in obtaining sufficient VGA page-white displays, according to Dataquest. Adds Grid's Walter: "They are available, but we wish we could get more of them." Compaq has also hired 135 manufacturing employees to help meet the underforecast demand for its laptops.

Conner Peripherals Inc. of San Jose, one of the largest hard disk drive makers for laptops, reports difficulties keeping pace with demand for its 3.5-inch drives, says chairman Finis Conner. Conner's drives consume less than 2 watts of power, a breakthrough that made hard disk drives functional in laptop packaging. But that benchmark is being challenged by PrairieTek. Its 2.5-inch drive, not much larger than a pack of cigarettes, consumes only 1.5 watts of power. PrairieTek expects to finish this year selling 160,000 drives. □

Lithium batteries rewrite the rules for laptop makers

NEC has bet on advanced lithium cells for its new laptop, and some board makers are doing the same. But lithium's lead is far from assured

BY BARBARA BERKMAN

These are turbulent times for the lithium battery industry. In the past two years, management shakeups, new suppliers and the first-time commercialization of lithium batteries for the consumer market are demanding heightened aggressiveness from lithium battery makers.

All of which has laptop computer makers and producers of other weight- and power-sensitive electronics equipment asking a lot more questions about the often-overlooked battery business: Should they follow the lead of NEC Corp. in betting on advanced lithium batteries? Will they obtain the same low-weight payoffs? And how can they learn to understand and then exploit this arcane new power technology?

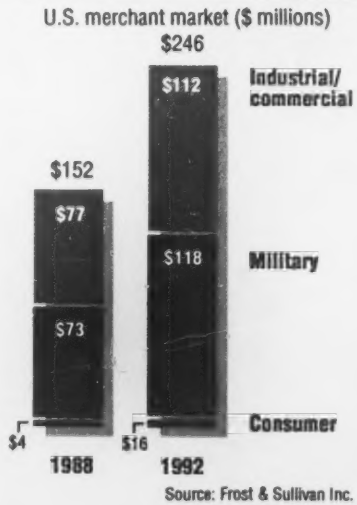
Up to now, nickel-cadmium batteries have been popular for laptops, military communications systems, add-in computer boards and a myriad other areas where low weight and long battery life are important. But the lithium lightweights last more than twice as long — 1.8 watt-hours against 0.85 watt-hours for the type used in NEC's laptop. And when NEC's choice of an advanced rechargeable lithium cell helped whittle its Ultralite to just 4.4 pounds, it rewrote the rules for competing in the fast-growing laptop market and added significant impetus to the battery makers' sales efforts.

It's not as if battery makers don't have enough to keep them busy. The entry of new players like Eastman Kodak Co., coupled with research that may spawn product development by such nontraditional battery makers as AT&T, have cluttered the market with competition. These newcomers' products are far from insignificant: last year Vancouver, British Columbia-based Moli Energy Ltd., supplier of NEC's batteries, shipped the industry's first commercial rechargeable lithium battery.

And among the giant battery makers, Ralston Purina Co.'s purchase of the Eveready Battery Co. from Union Carbide Corp. in 1986, followed by the mid-1988 leveraged buyout of Kraft Inc.'s Duracell unit, have placed two major suppliers in the hands of new management.

But a lithium battery industry in flux is a boon to electronics manufacturers scanning the market for improved batteries. However, in the race to commercialize new products for miniaturized, portable electronics, development times typically have been slashed to under 18 months, down from as much as four years. And for the first time, joint ventures and nondisclosure agreements between OEMs and battery suppliers have become de rigueur.

Lithium battery uses



"Companies are working on new OEM products and new power sources simultaneously," says Barry Huret, assistant general manager of battery sales at Panasonic Industrial Co.

No complacency, please

Indeed, because of the number of new battery products now being commercialized, there is little room for complacency among OEMs. "No potential battery user can afford to keep out of touch with what suppliers are working on in their labs," warns Donald Saxman, editor of Houston's "Battery & E.V. Technology."

Designers from the two industries, however, haven't always worked in tandem. It is a relationship "ripe for miscommunication," explains Michael Bolan, vice president for marketing and development of Dallas Semiconductor. "There's a teaching and education process that the community of lithium battery makers and engineers must go through."

At no time has that learning process been more critical. Industrial battery suppliers are aiming their products at high-margin, high-end applications that pivot upon a close partnership with manufacturers. To succeed, suppliers are bridging the gap between electronic designers' specifications and lithium technology. "Battery development has progressed much less quickly than electronics," says Ken Rekrutiak, marketing vice president of Moli Energy.

Nonetheless, lithium battery sales are growing at 13% to 16% annually, fueled by their improved performance, new applications and the general miniaturization of electronic products. The U.S. market could reach $246 million by 1992, up from an estimated $152 million last year, according to New York market researcher Frost & Sullivan Inc. In

Europe, sales last year of $61 million — with some $34 million fueled by memory backup applications — will mushroom to $104 million by 1993.

Domestically, the use of lithium batteries in computer add-ons is also outpacing growth in other industrial applications. The batteries serve as back-up in case of power failure in systems using CMOS RAM chips.

The U.S. merchant market for lithium batteries is almost evenly divided between industrial and military applications, with each generating some $75 million in sales. Leading suppliers in the industrial market are Wilson Greatbatch, Tadiran Electronic Industries Inc. and Panasonic, while Power Conversion, Duracell Inc. and Saft America Inc. dominate supplies for military applications, according to Frost & Sullivan.

The most explosive growth will be in consumer sales of mass-marketed commodity lithium batteries retailing at a pricey $5 per package. Battling for share in a market predicted to quadruple in sales over five years to $16 million by 1992, are Kodak, which launched a 9-volt battery in 1986; and Duracell, with its line of 3- and 6-volt products. Eveready will foray into the market with a 1.5-volt AA battery due in early 1989.

Yet, the surge in consumer sales will have an impact on industrial market prices because the production processes are different. Industrial suppliers are plowing research dollars into a host of high-end applications: electronic transmitters, digital tape measures, automatic tire pressure equipment and hearing aids that monitor frequency amplification.

Higher volumes

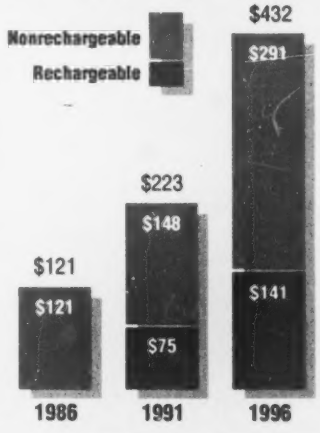
"Potential applications are turning into real applications," promises Edward S. Hatch Jr., marketing manager for industrial batteries at Catalyst Research Corp., a Baltimore-based lithium battery maker. Increased sales volume, as well as improved manufacturing automation, already have helped slash prices on high-volume cells. Recently, Saft, a Valdosta, Ga., supplier, lowered year-end prices by as much as 60%.

While the electronic industry should be hitting paydirt as more lithium batteries trickle into commercial development, some products approach the needs of industrial users — but are still not close enough.

Take the example of chip makers Dallas Semiconductor and SGS/Thomson Microelectronics Inc., two pioneers in packaging semiconductors together with lithium batteries for use in computer board real-time clocks. Dallas Semiconductor's integrated product is smaller than the components purchased separately, and pricer at $12.50 for 1,000 units. Manufacturers benefit from a lower part count and convenient installation. "We don't have to be familiar with lithium technology," says John Rynearson, vice president for engineering at St. Paul, Minnesota-based board maker Mizar Inc. "Our designers get all the specs, they stick it in, and that's it."

Lithium battery sales

U.S. market ($ millions)



Source: Business Communications Co.

Ideal in concept, the actual parts sport some unwieldy features. "Their products have been close, but not quite right," says Force Computer Inc. senior engineer Jim Turley about Dallas Semiconductor's product. He adds the "nonstandard package size, nonstandard device pin-outs and cumbersome programming interfaces conspire to make the part hard to love."

Still, the chip makers' integrated products are gaining market share, and battery suppliers are also muscling into the laptop market with rechargeable lithium cells. When NEC introduced the Ultralite last November, other laptop makers sat up. "We could see switching over," admits Mark Schiebl, product market manager for Grid Systems Corp., a maker of high-performance laptops.

Rechargeable lithium battery technology is compelling. Unlike alternative batteries, lithium's chemistry lends itself to a gauge that lets laptop users know exactly how much charge remains to power the computer, an attractive feature for intermittent users. While priced at $4-$5, as much as 3 times the price of nonrechargeable lithium cells, one Molicel is 65% lighter and one-half the volume of two nickel-cadmium batteries.

Airline restrictions

Yet only a handful of suppliers Altus Corp., Sanyo Energy Corp., EIC Laboratories Inc. among them — are researching or sampling lithium rechargeable batteries. Many others are shunning the technology completely, and for some sound reasons. Federal restrictions limit to 0.5 grams the amount of lithium, per battery, that can be carried on airplanes. NEC secured a waiver of the restrictions, an "arduous," but inevitable process that would be a hurdle for all laptop makers following NEC's lead, warns Paul Cereiko, product manager for the Ultralite.

The recharger itself weighs more than one pound, sacrificing some of the benefits of the lighter lithium battery. The cells also have a wide range of discharge, between 2.2 and 1.3 volts, compared with a flat discharge rate for nickel cadmium, the prevalent laptop power source. Improvements in nickel cadmium technology are also making laptop makers think twice. "Nickel cadmium makers have cranked another 20% capacity out of the same cells each year. It's a race," says Grid Systems' Schiebel. "We need a big jump in cost, performance and advantages to consumers before we shift over."

If they do switch to lithium, laptop makers may well encounter limited suppliers for some time. "Right now, lithium rechargeable batteries is a very small niche inside a very small niche," quotes Gilbert Merritt, Eveready's director of technical resources. That marketing decision may be a laptop maker's lament. Says Cereiko: "Battery manufacturing is critical to laptops," but the ideal battery seems yet to come. Cereiko's wish list? "I'd like them lighter, smaller and more powerful." □

Promise and peril for makers of VME board-level computers

Industrial manufacturing continues to pull VME board-level computer growth along. But the low end may be under attack from the ATbus

BY RICK WHITING

A maturing market, a possible shakeout of weaker companies, and a bid to define the future VMEbus architecture all mean that for the VME board-level computer market in 1989, the times they are a-changing.

In 1988, the worldwide market for VME-based products is estimated to have reached some $420 million, with board-level computers (sold for incorporation into complete systems by OEMs) accounting for $135 million of that, according to the VMEbus International Trade Association (VITA). "And there is a near consensus that the VME market's compound annual growth is 31% to 32%," says analyst Rick Main of Databus Market Reports, Santa Clara, Calif.

This year holds promise for VME vendors. Their chief market, industrial manufacturing, is booming, and the 32-bit VME standard continues to make gains against Intel Corp.'s Multibus and other architectures.

But on the down side, there are signs that microcomputer buses are becoming more competitive at the low end. And despite the market's growth, some of the hundreds of smaller companies that compete in the VME board-level computer arena could fall by the wayside as the market is transformed from being technology driven to marketing driven.

"I think there is consolidation within the VME market," says Martin J. Weisberg, executive vice president and general manager of Force Computers Inc., based in Campbell, Calif. "A shakeout is underway [and] we're expecting that to accelerate."

Since its creation in the early 1980s, the VME single-board computer market has become dominated by Motorola Inc., Force, and a handful of other companies. But the huge majority of vendors are small operations, some recording only six-figure annual sales.

Pete Yeatman, marketing vice president for Radstone Technology Corp. in Pearl River, N.Y., believes that despite the market's growth, it is not enough to support the hundreds of vendors competing for a share of that business. What's more, large system vendors such as Masscomp (now merged with Concurrent Computer Corp.) and Sun Microsystems Inc. are increasing sales of VME single-board computers.

"As companies become larger, the business side becomes more important," according to Main, referring to marketing, sales and even legal operations. "That will make it much more difficult for the small guys to compete. With the maturing of the market [and] the sophistication of the customers and competitors, it's certain to drive out some of the smaller companies that are not as competitive.

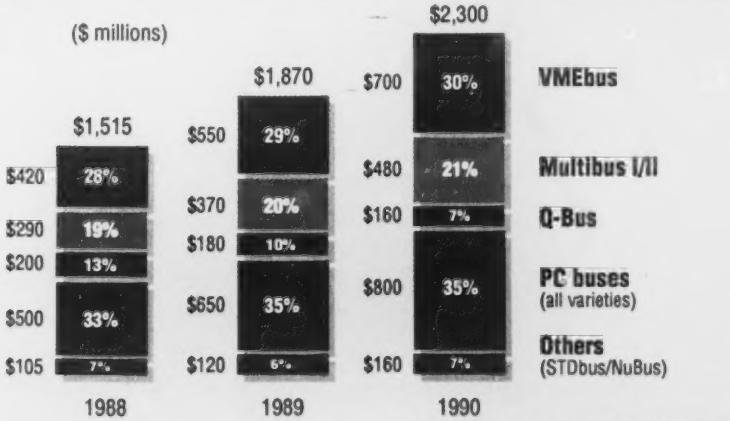
More lawsuits

"And what that means is that we'll see more lawsuits, we'll see lower prices, and we'll see better engineered products and more complete products," says Main. He also predicts greater emphasis on customer service and support, rather than hot technology. "Many vendors are so engineer dominated that they do not even understand the market," he says.

Even leading-edge engineering is putting the squeeze on small companies. Weisberg notes that surface mount technology, software, and gate array design are becoming increasingly expensive and small manufacturers cannot afford the cost.

Furthermore, Motorola does not disclose sales figures, but the company claims to hold a 40% share of the VME board-level computer market, according to Fred Rehhausser, strategic marketing director for Mo-

Worldwide board market by bus architecture



Source: VMEbus International Trade Association

torola's microcomputer division.

With 1988 sales of some $60 million (including all VME products), Force claims a 25% share of the VME CPU market. Radstone and Heurikon Corp., Madison, Wis., both claim to hold the third position. Radstone puts its annual sales at about $50 million and Heurikon at $20 million, although neither breaks out VME board-level computer sales or provides market share estimates. Other players include Dy-4 Systems Inc., Ironics Inc. and Mizar Inc.

Formerly the microsystems division of The Plessey Company Plc, Radstone is itself a creature of the evolving market. Plessey had planned to close down the unprofitable division, according to a report prepared by Main, and the division's managers executed a leveraged buyout last May. Radstone Technology Corp. is the U.S. subsidiary of British parent Radstone Plc.

But VITA director Lyman Hevle remains upbeat about the VME market in 1989, believing that the growth rate precludes the possibility of a shakeout. "The market has expanded as fast or faster than the total ability to produce product," he argues.

Industrial automation is the largest market for VME board-level computers and Hevle points to the resurging manufacturing arena as a reason for optimism. Because VME is an accepted industry standard and the architecture is designed for rugged applications, sales to the government and the military are also on the rise.

Yeatman, for example, says that 40% of Radstone's VME board-level business is commercial and manufacturing, 40% is military-related, and the remaining 20% is comprised of "ruggedized" systems for special industrial applications.

Real-time computing appears to be the fastest growing area for VME board-level computers, according to marketing executives at Force, Motorola, and other vendors. "Real time is becoming much more of a strategic market for ourselves, our competitors, and Sun, of all people," Rehhausser says.

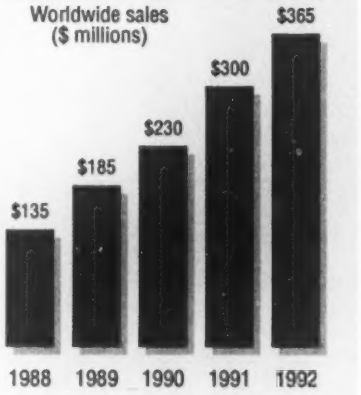
Open hardware

Weisberg says that many users and OEMs that previously relied on proprietary bus architectures are switching to VME CPUs. "I think that thanks to the OSF (Open Software Foundation) and Archer groups, openness is becoming an issue," he says. "More and more of our customers are looking at open hardware as well as open software."

The venerable Multibus I standard promoted by Intel remains a strong seller because of its huge installed base among low-end systems. But the jury remains out on the sequel — Multibus II.

Venture Development Corp. division manager Maurice Klapfish, who follows the VME market, believes that Multibus II is gaining ground within high-end applications and is putting competitive pressure on the VME architecture. But he says it is too early to say if Multibus II will ever overtake VME. Hevle and Main, however, are more skeptical about the eventual success of Multibus II.

VME-based CPU market



Source: VMEbus International Trade Assoc.

"VME will be the lion's share of our business [this] year," predicts president Christopher Priebe of Heurikon, which markets VME, Multibus I and Multibus II board-level products. Radstone markets only VME-based boards and Yeatman agrees: "We get very little or no competition from Multibus II."

Threat to VME

But VME boards are facing a threat from another quarter: the ATbus, NuBus and other microcomputer architectures. Priebe believes that rather than migrating to the higher VME architecture as expected, many current vendors and users of Multibus I are switching to the ATbus.

That does not come as a surprise for Yeatman, who says that for applications not requiring the high throughput or rugged architecture of VME, the cheaper AT architecture makes sense. "If I can do the kind of processing that I need to do on an IBM PC, I'd be a complete idiot to buy a VME product," he says.

For the future, VITA and VME product vendors are seeking to keep the architecture intact by defining the future of the standard and providing technology bridges for migrating from the current specifications.

At VITA, business and technical committees, chaired respectively by Weisberg and Shlomo Pri-Tal, Motorola's manager of systems architecture, have been meeting to define the future standard. In December, VITA decided to base the new architecture on the Rugged Bus and Future Bus specifications established by the IEEE. Hevle says the results, due for release by mid-1989, will result in a bus architecture with "10 times the speed" of the VME's 40 megabytes-per-second throughput.

"What this means is that we can reach applications that we could not even touch with VME," Hevle says of the implications for board-level computer vendors. VME will be repositioned as a midrange or intelligent I/O bus.

Yeatman believes the current standard will still be good for design purposes for about three years. But Priebe says that with powerful RISC (reduced instruction set computer) microprocessors, the likely foundation for future single-board CPUs, a high-performance bus architecture will be a necessity.

While calling the VITA plans "a laudable effort," Main is skeptical that any committee can prescribe a future standard. "They can decide what [the standard] ought to be, but that isn't how the market works." He sees the future bus architecture being shaped by user demand, competition from proprietary architectures and the wishes of major semiconductor vendors — in this case Motorola.

This month Hevle and his equivalent at the Multibus Manufacturers Group will meet at the Buscon show in Santa Clara to discuss the possible merging of efforts to define future standard bus specifications. "Our common enemy is proprietary buses in the open market," he says. □

Semiconductor makers bask in the Italian sun

While worldwide chip sales are cooling, they're still hot in Italy. Last year's 50% growth was attributed to the booming domestic high-tech and auto industries

BY ANDY ROSENBAUM

As the gloom begins to gather over the worldwide semiconductor industry, sunny Italy is likely to remain a hot spot. While integrated circuit demand in Western Europe is expected to slow to 11% this year, sales within Italy will increase almost 21% to $1.01 billion, according to Motorola Inc.'s annual survey. What's more, this growth comes on the heels of a 50% jump in 1988.

In general, Italian business is booming, led by a dramatic upsurge in demand for cars and personal computers. Industry is spending up to 10% of its income on capital improvements, a record high for Italy. As a result, the once decidedly low-tech country is starting to catch up with its neighbors. One of the biggest beneficiaries of this boom is SGS Microelettronica SpA, Italy's homegrown supplier which is now part of semiconductor heavyweight SGS-Thomson. SGS controls about 15% of the Italian market, which represents about 17% of the chip maker's $1 billion in sales.

Memories comprise a full one-fourth of SGS' Italian demand, according to Jean Phillipe Dauvin, SGS' chief corporate economist, with microprocessors representing 21%. SGS is optimistic that the growth will continue at a healthy clip. David Gibbons, an analyst with James Capel in London, agrees. "While demand for PCs should not equal that of 1988, there is a consistent need, in both terminals and PCs, for more memory per user," according to Gibbons.

Oliver Martin/Black Star

SGS economist Jean Phillipe Dauvin: "Italian electronic industries are growing faster than their European competition"

PCs in demand

Ing. C. Olivetti & Co. SpA sold about 500,000 personal computers in Italy last year, according to industry sources, despite problems in obtaining DRAMs. "Memory scarcity has had little effect on Olivetti because we have always had long-term contracts with our suppliers," explains Olivetti semiconductor purchaser Piero Giannatempo. "This is equally important since we have to pay special attention in trustworthiness and qualification of our suppliers. So we try to avoid the spot markets."

In addition to information-processing applications, the auto business is stepping up its demand for "smart" electronics for cars. "Almost 30% of our sales go to this sector, in which we expect a steady rise," says Siemens Data SpA commercial director Bruno Fumagalli. The Italian car market is outpacing the European market's boom. While European sales grew 5% in 1988, according to DRI Europe, sales in Italy grew 7.4%.

This is good news for Fiat, which has a lock on more than 60% of the Italian car market. Magnetti Marelli SpA, Fiat's component unit, spent about $40 million on semiconductors last year. "And we expect a 20% rise in sales in 1989," according to business manager Bruno Pechiney. "Up to now we have not had trouble in obtaining supplies," he adds, "since we don't require standalone memories, which have been in short supply." The Fiat unit is Europe's second auto component maker. According to industry analysts, it controls about 56% of the original equipment manufacturers' market for fuel management systems; 50% of Europe's market for dashboard systems; 37% of

all steering-column switches; 31% of all headlight systems; 25% of all starters; and 20% of all electronic ignition systems.

Across-the-board investment

Although Fiat is easily Italy's largest company, it is not the only large company here that is spending heavily to catch up in high tech. Industrial leaders spent $3.5 billion (in a country of 56 million people) on data processing and telecom in 1987. "Italian industry is restructuring on the back of strong export demand," says UBS-Phillips & Drew Ltd. analyst Richard Reid. "The battle with unions has been won, and operators are making up for years of underinvestment. They are seeking more professionalism and more marketing, and that means more high tech."

Upgrading and expanding manufacturing accounted for 72% of that high-tech investment. CAD/CAM alone was worth $270 million. "Factory automation is a high-growth area, especially when it can be linked to administration," according to a report by Assinform, an association of data-processing managers. "Integrating office and production management should involve heavy investment for Italian industry."

However, Italian banks also are investing quite heavily in high-technology products. "Italian banks are among the world's most labor-intensive and least efficient credit institutions," according to Gianni Allavena of Milan's SIGE investment firm. "With the specter of 1992 looming, Italian banks are beginning — but just beginning —to computerize."

Networking should also constitute a high-demand area for banks in the coming years. However, the supply of extra services will also require better-functioning telecommunications networks, above all for electronic fund transfer, and Italy's public network currently leaves much to be desired. "The high performance of Italian industry and its increasing adoption of information technology contrasts strangely with the backward public network — either in terms of telephones or of packet switching," according to Milan Technibank analyst Franco Morganti.

IC demand in Italy is expected to increase almost 21% according to one survey

Meanwhile, analysts are projecting substantial spending increases in the services sector, which spent about $150 million for information-processing equipment in 1987, according to the Assinform study. In areas where computers are critical, only 50% of the operators use information technology in Italy. And success in furnishing VAN services is only partial. Evolved forms of processing such as office automation, computer graphics, scientific calculation and archiving have achieved "surprising little diffusion in the service sector," according to Assinform.

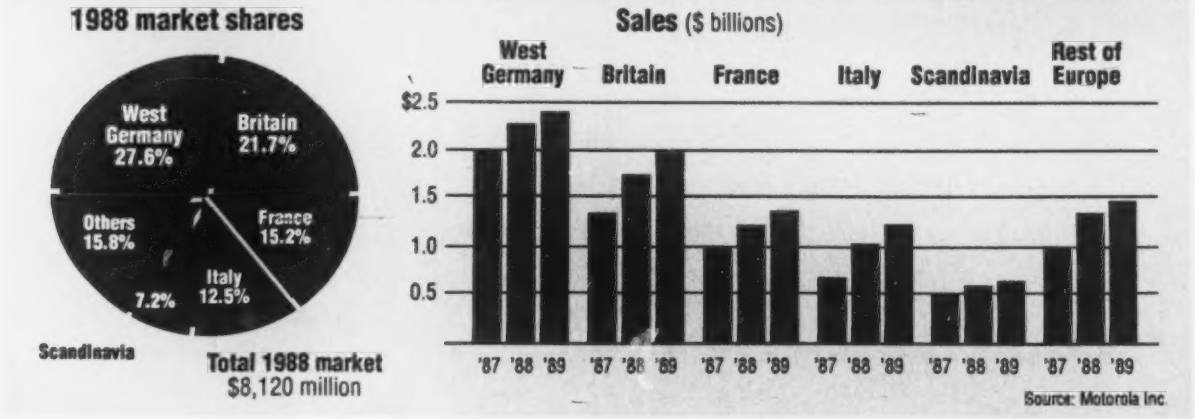
And, in an effort to make its byzantine bureaucracy function more efficiently, the Italian government spent about $1.5 billion in information-processing equipment last year, up 11%. In an attempt to bring government departments on line, the Ministry bought 12,000 personal computers in 1988, 140% more than in 1987, with a corresponding investment in networking technology.

Despite their agreement about the bright local scene for semiconductor sales, SGS and Motorola concur that the worldwide market will grow much more slowly next year. "The coming year will be difficult for the entire semiconductor industry," says SGS managing director Pasquale Pistorio. "We expect computer sales to fall, and growth to be only at about 6% to 7%."

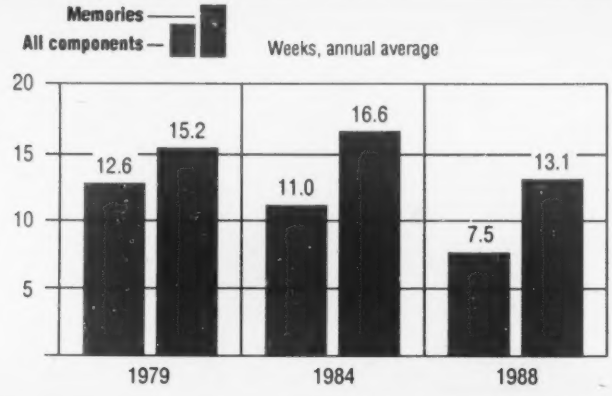
From the vantage point of his Paris office, SGS' Dauvin is a paragon of measured optimism. "Since the Japanese will continue to increase capacity, I expect that the price of semiconductors will fall," he says, "with the 1-megabit DRAM going from about $25 now down to about $15. Obviously that will bring the overall value of the Italian market down." Still, overall volume of sales should remain high," according to Dauvin. "Italy's solid economy ensures that growth will not slow too much," he explains. "And Italian electronics industries are growing faster than their European competition."

At least SGS executives can count on their local market to run counter to this depressing general trend. □

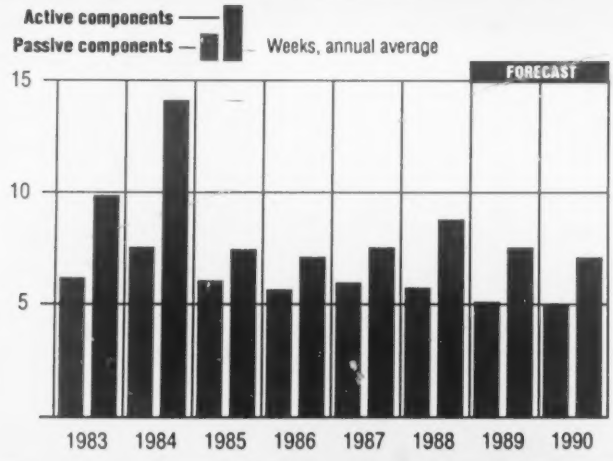
The European semiconductor market by country



Comparing leadtimes during expansions



Component leadtime outlook



Leadtimes in detail

Weeks, monthly averages	Peak 1983-1984	December 1987	December 1988	1st qtr. 1989
Discrete semiconductors	11.6	8.4	5.5	5.7
Integrated circuits	19.6	7.6	4.6	5.1
Memory circuits	20.4	9.6	9.7	6.9
Microprocessors	24.6	8.6	8.9	6.4
Displays	10.4	9.1	7.3	7.2
Capacitors	10.0	6.9	5.3	5.4
Connectors	10.1	7.2	5.2	5.4
Printed circuit baords	9.4	5.9	5.5	5.2
Relays	11.8	8.1	5.5	6.7
Resistors	8.3	4.6	4.2	5.1
Switches	8.3	6.4	5.5	5.5
Wire and cable	6.7	4.1	3.4	3.5

Historical data: Electronics Purchasing; Forecast: Cahners Economics

Leadtimes reveal some information about outlook

Leadtimes for electronic components averaged seven and a half weeks in 1988, far below the leadtime stretches of previous electronics industry expansion years. That's telling us something about the type of economic recovery the industry went through and what we may expect in 1989.

These leadtime statistics presented here are average length of time between a buyer's placement of an order and the seller's delivery. ELECTRONIC BUSINESS' sister publication, *Electronics Purchasing*, surveys over 500 buyers each month to determine how speedy or slow components are being delivered. The result of this survey: exclusive average monthly leadtimes for over 80 types of electronic components.

This leadtime data offers a snapshot look at demand for a product relative to supply. Back in April of 1984, when supplies were short and demand was high, delivery times for microprocessors stretched to over 25 weeks. A year earlier, buyers of microprocessors had only to wait nine weeks for delivery. Clearly, the supply was completely out of alignment with demand in 1984.

For 1988, the leadtime data is telling a far different story than in 1984. Last year, the highest microprocessor delivery time reached was 10.3 weeks, in August. Indeed, delivery times have been amazingly stable.

The numbers reveal some hints about what to expect this year as well. Because supply and demand have stayed in relative balance, end users have not built up excessive inventories. Back in 1983 and 1984, buyers double- and triple-ordered to protect their production schedules. Not so in 1988. The upshot is that there will be no inventory-led components sales crash this year.

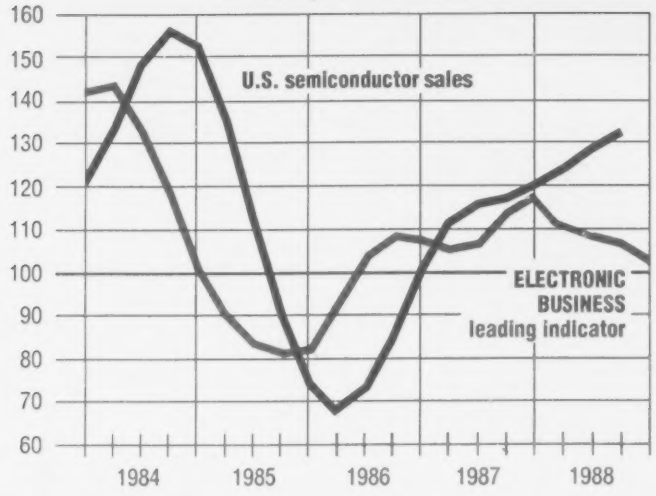
Just-in-time (JIT) inventories have also helped to keep delivery times low in 1988. With a commitment to JIT and now some experience under their belt, electronic manufacturing companies have simply not allowed delivery times to stretch to 1984 highs.

ELIZABETH B. BAATZ

Leadtimes will appear again in the May 1 issue of ELECTRONIC BUSINESS. Note: A monthly subscription to *Electronics Purchasing*'s leadtimes database is available on IBM-compatible diskettes for just $275. To order, or for more information, call Gina Roos at *Electronics Purchasing* at 617-558-4731.

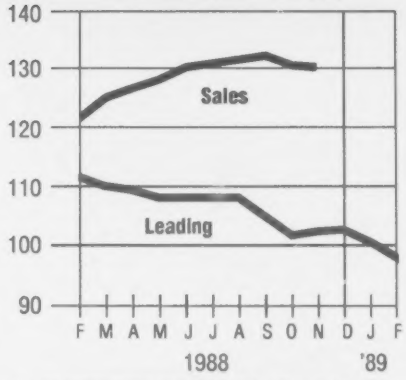
ELECTRONIC BUSINESS leading indicator

Quarterly (rate-of-change)



The ELECTRONIC BUSINESS leading indicator predicts turning points in U.S. semiconductor sales with about a three- to nine-month leadtime. For more information please contact Elizabeth Baatz, senior economist, Cahners Publishing Co., 275 Washington St., Newton, Mass., 02158, or call (617) 558-4368

Monthly (rate-of-change)



The ELECTRONIC BUSINESS leading indicator fell to 102.2 in October, down from 105.6 the previous month. Unlike past months, all the components of the indicator contributed to the decline, with semiconductor bookings and company stock prices contributing the most to the fall. The business cycle trough for semiconductors will happen in the first quarter of 1989.

Source: Cahners Economics

Electronics industry indicators this month

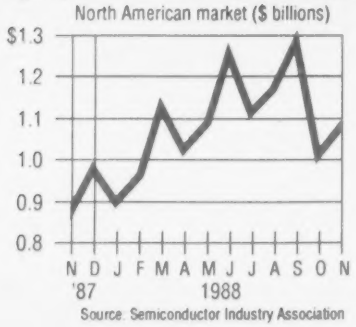
	Latest month	Previous month	Year ago	1987 average
ELECTRONIC BUSINESS leading indicator (rate-of-change, Oct.)	102.2	105.6	119.9	111.1
U.S. semiconductor bookings ($ millions, 3-month average, Nov.)	$1,071	$1,064	$999	$951
Weekly hours of semiconductor production workers (monthly average, Oct.)	39.7	39.9	40.4	40.6
Electronic components leadtime index (1977 = 100, Dec.)	89.8	99.8	109.3	100.7
S&P's semiconductor stock price index (1970 =10, monthly average, Nov.)	44.2	48.1	51.1	65.5
Change in electronic components inventories ($ millions, SA, Oct.)	+$96	+$61	+$93	+$41
Contract and orders for plant and equipment ($ billions, SA, Oct.)	$37.8	$39.2	$35.5	$34.6

SA = seasonally adjusted, all other data is not seasonally adjusted

Sources: Semiconductor Industry Association, U.S. Bureau of Labor Statistics, *Electronics Purchasing* magazine, Standard & Poor's, U.S. Commerce Department, U.S. Bureau of Economic Analysis

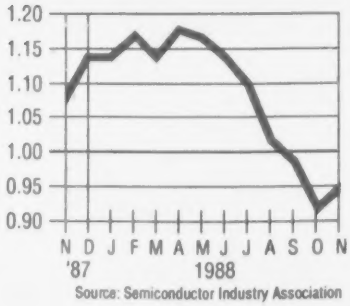
Semiconductor sales

North American market ($ billions)



Source: Semiconductor Industry Association

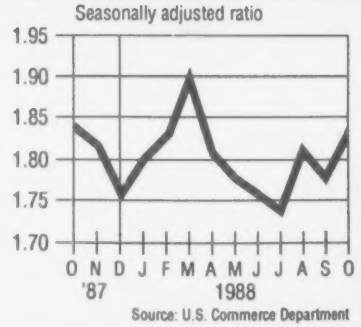
Semiconductor book-to-bill ratio



Source: Semiconductor Industry Association

Component inventory-to-shipments

Seasonally adjusted ratio



Source: U.S. Commerce Department